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The traditional, the transitional, and the technological classrooms are looked at to perceive the change taking place in the educational setting. The traditional classroom with its curriculum is teacher-oriented and self-contained. The teacher is the channel of communication between the makers of the curriculum and the student. Some teachers may allow considerable experimentation by pupils; others may use such audiovisual aids as television for enrichment purposes.

In the transitional classroom, the television set and programed instructional devices are evident. Such a classroom is no longer completely self-contained. Here an important segment of one or more subjects is taught on a predetermined basis in some way other than by the traditional classroom exchange. The portion of the curriculum so taught is substantial, and the use of the technique is predetermined and not at the option of the teacher. Curriculum makers must provide materials to be used in conjunction with the teacher, not by the teacher.

The technological classroom of the future will be a complex of teaching techniques of great diversity and flexibility. Emphasis will be on discovery teaching, or an attempt to help pupils understand the intellectual means through which new knowledge is discovered. Predictions are that the one classroom to which the child is restricted will vanish, and workrooms equipped with tools of the trade in each subject will develop.

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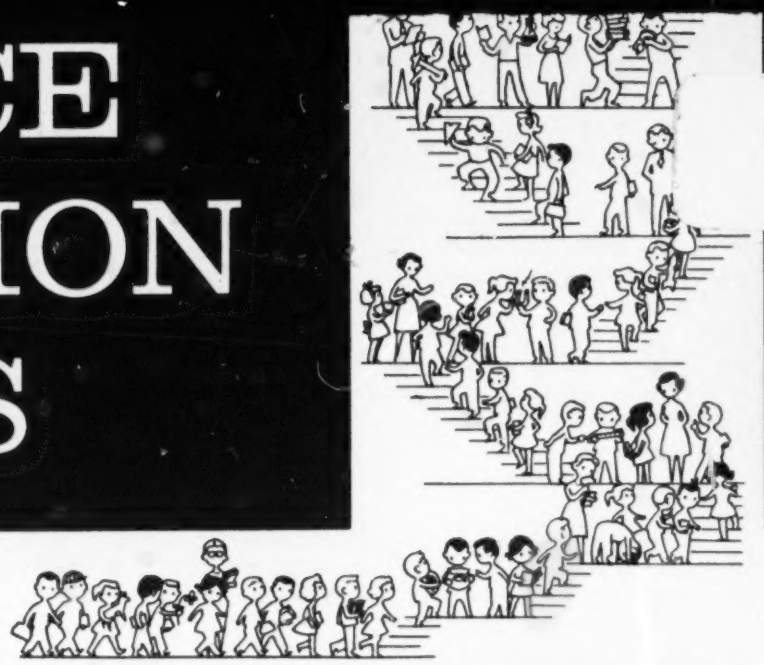

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Science Curriculum Revision and the Technological Classroom

E. G. Sherburne, Jr., Director of Studies on the Public Understanding of Science, AAAS

The revolution in the organization and structure of the subject matter of science as taught in the schools must now be matched to another revolution in education—the technological classroom. What is the relationship between two such seemingly disparate educational developments?

All would agree that a significant milestone in science education was established with the new science curriculum revision projects. Scientists, working alongside teachers, educators, and specialists in educational techniques, are updating and improving the content of science and mathematics in the school curricula. These activities are taking place for many scientific disciplines for use at levels from kindergarten through the high school.[1]

Emphasizing the organization and content of scientific knowledge, these projects have provided a remarkable response to the need for better science in our schools, and have introduced a quiet revolution, based on a concern with the subject matter of curricula. A number of unifying, lively and instructive textbooks have been produced and others are in preparation. Laboratory experiences have been updated, and made more integral to learning and to the courses of study.

Emphasis has been placed on teaching the process of science in contrast to pure facts. Teachers have been given opportunity to improve their understanding of science and of the new courses through summer institutes. Audio-visual techniques have received some attention, mostly in the form of films conceived of as enrichment and in some cases, as adjuncts to the classroom teachers. Some of these films, such as the Physical Science Study Committee productions, have established a new standard of excellence for teaching films.

To improve the content of the science curriculum and to modify it to correspond with current scientific sophistication has been a monumental task. And it is one that will never be completed, for scientific knowledge is doubling approximately every ten years, and exercising an increasingly important influence on our technological society. Thus, science curriculum studies must continue, albeit intermittently, for the foreseeable future.

But they must not continue on their present basis —there must be a widening aspect to their concern. The organization of courses and correlated materials coming out of most present studies are primarily designed for the traditional, self-contained, teacher-oriented classroom. There is now a need to combine the subject matter studies with a realization of how far many American classrooms are already removed from the traditional classroom situation, and with a vision of where the classroom may be headed in the future.

Unless this is done, curriculum revision materials will not be used widely enough to have the needed impact on learning. Instead, schools will move ahead with their own answers to their problems

[1] Some 30 such projects were reported in *Science Education News*, December 1961.

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(of which the curriculum is only a part), using curriculum materials sporadically where they can be fitted into the new educational setting.

The change which is taking place in the educational setting can best be perceived by taking a look at three classrooms which represent the present and the future: the traditional classroom, the transitional classroom, and the classroom of tomorrow which might be called "the technological classroom."

The Traditional Classroom

The traditional classroom and its curriculum (or what the teacher uses when he teaches [2]) is a teacher-oriented, self-contained situation. The interchange is primarily between teacher, pupils, textbooks, and other materials which can be selected at the option of the teacher for introduction into the classroom. (The word "traditional" is used of course in a purely relativistic sense, and not to imply that there has always been one typical kind of classroom up to the present.) The teacher-oriented classroom can vary according to the teacher and the situation, some allowing more experimentation by the pupils, others using more audio-visual aids such as television employed as adjunct to the curriculum for enrichment purposes.

In the traditional classroom, the teacher stands as the clearly defined channel of communication between the makers of the curriculum and the student. He (or she) must singlehandedly meet the individual differences of pupils, the demands of many courses of study (if an elementary classroom), the utilization of new or old pedagogical techniques, the uses of materials and visual aids, and the modification or general acceptance of textbooks. To affect the traditional classroom, one must essentially reach every teacher, then put into his hands the traditional materials he can manipulate. This is the situation which the curriculum projects seem so far to have envisioned.

Now let us examine the transitional classroom. Here, the television set might be called the symbol. There are far more transitional classrooms than one may realize, since they include a substantial portion of those classrooms containing the 6,000,000 students who in the fall of 1962 will receive some of their instruction by television. In this category, there is no typical situation either. It may vary from an elementary classroom receiving science instruction three times weekly via TV, to a high school classroom utilizing a complete television sequence of physics lectures.

Another symbol has already entered the transitional classroom to compete with the television set. Programed instruction is being used in schools at a rapidly increasing rate: there are 30 major testing projects under way this fall, and 23 science and 53 mathematics programs are available to educators today. Here, in opposition to TV, is a device that centers on the individual student and his responses to item-by-item information presented in successive patterns.

It is clear that the teaching situation in the transitional classroom is different. It is no longer as self-contained as the traditional one. The transitional classroom might be defined as the situation where an important segment of one or more subjects is taught on a predetermined basis in some way other than by the traditional classroom exchange. Note that the portion of the curriculum taught is substantial, and that the use of the technique is predetermined and not at the option of the teacher. This means in its fullest implication to curriculum makers that to influence the curriculum, one must provide materials for use in conjunction with the classroom teacher rather than by the classroom teacher. Most curriculum revision projects have not done this.

The Economic Factors

Some subject-matter curriculum builders may even be puzzled. Why have school systems so readily embraced some of the new media? A broad summary of most research on television and films (and on teaching machines, though not so extensive) shows that students learn from these media as well as in traditional situations. The recurrence of the statement "no significant difference" in the results of testing therefore must indicate that the use of these devices is based on something other than a purely qualitative decision.

The decisions in most cases are based on logistical (usually economic) reasons, where administrators and school systems have projected their problems ahead twenty years instead of five. They see the necessity of incorporating all the technological help at the disposal of the schools in order to meet the demand of teaching more information better to larger and larger numbers of students. It is in no sense a question of replacing the teacher.

The economic realities have great significance to curriculum makers, since these realities in turn determine the classroom realities. When a school system commits itself to the extensive use of a medium such as television, it is making a financial investment in broadcast or closed-circuit equipment, or in a subsidy to an educational television organization. The commitment means investing in classroom receiving equipment, and subsidizing program production or renting or purchasing recorded programs. Once these investments are made, they are not lightly discarded, and their existence becomes a basic influence on the design for teaching of a school system.

When a school system adopts a communications medium for teaching, it also adopts the kinds of messages available for dissemination through the medium. Thus, school systems find themselves in the position of adopting, along with television, film, or programed instruction, the materials which these devices use. But vastly more important, the school systems find themselves adopting new curricula determined by the use of the materials, since there is no way of sidestepping or ignoring the influence of an hour of television, film or programed instruction when they are used as an integral part of instruction. In the past, the teacher used the media to enrich or supplement something presented by the teacher. Now, the teacher must build his presentation on the material presented by the media.

Science curriculum revision projects should be concerned with the design of curriculum materials which will fit the devices of the transitional classroom. And they should be concerned about the wide range of quality in materials which are being used or are available now, since these materials are having a strong effect on present curricula. But that is not all.

What about the technological classroom, the one of tomorrow? To exercise any influence on it, the curriculum re-

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EDITOR'S NOTE: This issue of SCIENCE EDUCATION NEWS, emphasizing the need to consider the resources of the new educational media in planning improved science courses, was prepared at the suggestion of the AAAS Cooperative Committee on the Teaching of Science and Mathematics.

[2] Wilhelm, Fred T. in "What are the Sources of the Curriculum, A Symposium." Association for Supervision and Curriculum Development, NEA, Washington, D. C. 1962, p. 14.

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vision projects should build their own vision of tomorrow, for unless they do, they will have to use the one which is presented to them. One should hasten to say that the technological classroom does not have to be the prototype of 1984, a mass production mechanical monster. Extrapolating straight from the master TV teacher and the TV set in a transitional classroom today is not the way to predict the technological classroom of tomorrow. Or at least, the technological classroom does not have to develop this way.

Every indication is that the growing technology which will be at the disposal of education tomorrow will be able to provide a complex of teaching techniques which has tremendous diversity and flexibility. If those who are concerned with the transmission of scientific knowledge can participate in designing the classroom of tomorrow, a truly "elegant" solution for science education might emerge.

Even more important, if some of the basic philosophy of current curriculum revision studies is to be put into practice, it must be implemented by the technological classroom. Emphasis on discovery teaching, or on the attempt to help pupils grasp the intellectual means through which new knowledge is discovered, can only have maximum realization in something other than the overcrowded, one-teacher, self-contained classroom.

J. Lloyd Trump has offered some suggestions of how he thinks the classroom of tomorrow should be organized in order to serve individuals better.[3] He sees the vanishing of the one classroom to which the child is restricted and the development of workrooms equipped with tools of the trade in each subject, in which pupils can work as individuals. While he does not emphasize the relationship of this ideal classroom with the technological classroom, the connection is logical.

The technical systems now being developed are opening the way to new schools. Miniaturization of equipment forecasts devices for recording, repeating and playing back that are relatively inexpensive, easily transportable, and operable by teacher and student alike. The workrooms and libraries will offer multiple systems of TV series, films for individual study, programed instruction. The systems will include the printed and spoken word, still and moving pictures in black and white and color, all instantaneously available for individuals or groups of any size. And there will be the opportunity of mixing and using all of these in any way desired.

These learning experiences can be pursued by students individually along with investigations for which appropriate materials and specialist guidance are available. A school whose physical layout permits diversification will offer for the first time in history an opportunity to practice what so many believe —namely, that there is not simply one method, one theory of learning, one behavior, that is applicable to every single type of individual, situation, and desired outcome.

[3] Trump, J. Lloyd, "Basic Changes Needed to Serve Individuals Better," Educational Forum, November 1961, pp. 93-101, and "Focus on Change—Guide to Better Schools," Rand McNally Company, Chicago, 1961.

Recorded Telecourses in Science and Mathematics

Working 40 hours a week, it would take 34 weeks to view all the available recorded telecourses:

	Series	Programs	Hours of Instruction
Elementary Mathematics	5	261	85
Elementary Science	19	832	471
Secondary Mathematics	3	113	66
Secondary Science	12	541	259
College Level Mathematics	4	207	103
College Level Science	8	761	380
Total	51	2715	1364

Source: *A Guide to Films, Kinescopes, and Videotapes Available for Televised Use.* Spring 1962. Instructional Television Library Project. New York, N.Y.; Lincoln, Nebr., Boston, Mass.

Tomorrow's Classroom

Imagine a student in the classroom of tomorrow. He can see and hear on demand a scientist telling about his own work. He can be inspired and stimulated by the lectures of skilled master teachers. He can drill at his own pace in subject areas which require skill and practice. He can become a scientist by discovery, finding out for himself in the science workroom some of the answers to questions which have been raised. And he can have a more rewarding relationship with his teacher, now become a teacher-tutor-mentor, who guides and supervises and participates in his various learning activities.

The transitional classroom which is with us today and the technological classroom which will be with us tomorrow provide a particular challenge to the makers of the science curricula.

Curriculum makers must accept, whether they like it or not, the educational realities of today, which include the increasing use of the new educational media. This means that there must be a fundamental concern for the kinds of packages scientific understanding comes in, as well as with the structure and nature of these understandings.

Curriculum materials must be provided in units which meet the requirements of the variety of classrooms in existence today. In addition to textbooks, laboratory materials, and enrichment films, there must be televised lecture series, programed instructional materials, film series. And these must be provided in quality and quantity to allow for choice in building curriculums in local situations.

Curriculum makers should have a greater awareness of and interest in the wide variety of curriculum materials which are available and being used in the educational media today. The range of quality of the materials is much wider than it should be. And yet there is at present no large-scale organized activity to provide evaluations of these materials. Something needs to be done to insure maximum utilization of the best of the available materials.

But the most important actions to be taken are for the future. If the concepts of teaching individuals to be active learners and creative members of a democracy are to be put into practice, many radical innovations will have to be made, including modifying the physical nature of the classroom and the role of the teacher. It is defeatist to assume that mass education can only be accomplished in a mass form. Technology can offer many ways to educate large numbers individually or in small groups.

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One must hope that scientists and educators will continue to engage in preparing materials for the classrooms of today, but on a wider basis, and more in keeping with the needs of the school systems. And one must hope that scientists and educators will at the same time help to provide more discrimination in the use of existing materials.

But the greatest hope lies in the possibility that they can find a way of becoming architects of the classroom of tomorrow, building an integral relationship between the instruments of teaching and the hard core of ideas which are to be taught.

Science and Instructional Television

Jack G. McBride, Director of Television and General Manager,
Station KUON-TV, University of Nebraska

• By means of a telephone company closed-circuit system and with special talk-back facilities in each classroom, professors at Purdue and Indiana Universities will present two graduate-level courses in radio astronomy for students at both campuses and at the Indianapolis Extension Center.

• From educational station KQED, the chairman of the chemistry department at the University of California at Berkeley will present a junior high chemistry course for over 100,000 students in the San Francisco Bay area.

• Through the Nebraska Council on Educational Television, Inc. and the cooperation of an ETV station, three translators and four commercial stations, fifth and sixth-grade teachers in 35 different school systems spanning the 450-mile width of Nebraska will prior to the school day receive in-service instruction from the elementary science specialist at the University of Nebraska Teachers College.

• From studios at the University of Alabama, Auburn University and the Birmingham Public Schools, and through four interconnected transmitters administered by a State Educational Television Commission, the Alabama ETV Network will program high school biology, chemistry and physics, elementary and junior high math and science to classrooms throughout 90 per cent of the state.

• Working from a special classroom guide, a gifted teacher will regularly step before the cameras of an Evansville commercial station to present intermediate and junior high science lessons to more than 30,000 students in 149 separate schools in the three states participating in the Southwestern Indiana ETV Council.

• In a Sioux Falls, South Dakota high school, laboratory demonstrations will be fed via cable to eight classrooms where 900 students in 30 sections will receive a portion of their biology instruction.

• About 5,000 college students preparing for teaching careers and high school teachers working for advanced degrees in education will rise early to view "Atomic Age Physics" as broadcast over the national network facilities of NBC as part of the *Continental Classroom* series with credit offered by over 265 colleges and universities throughout America.

• From a videotape recorder and transmitter in an airplane circling lazily over Indiana farmlands, students in six midwestern states will receive six science courses as part of the Midwest Program on Airborne Television Instruction, Inc. (MPATI).

The preceding paragraphs present a glimpse of the scope of instructional television as used in American education today. They also serve to illustrate the various types of television facilities and programs to be found as the carillon bells and gongs and buzzers of America's educational institutions open the 1962-63 school year. Educational television, born and reared in the decade of the 1950's, has passed the experimental stage and taken its place as an integral part of the American educational program. Because it has grown so rapidly, the scope and variety of educational television are frequently not realized.

What is Educational Television?

Basically educational television as known in the United States is programing primarily for educational intent—programing designed for two purposes:

1. An out-of-school informational and cultural broadcast service for people of all ages.

2. An in-school instructional television service for all levels of education. While the growth and acceptance of noncommercial informal afternoon and evening programing have been substantial and the alternate broadcast service forms a vital part of the national educational television scene (and provides many benefits for science), this report must restrict itself to formal and systematic instructional television, or ITV.

Instructional television in the United States is presently distributed by five methods:

1. *Through educationally operated noncommercial broadcast stations.* To date, 70 channels are operative. Licensees are school systems, universities and colleges, state educational television authorities and commissions, nonprofit corporations and associations, state departments of education, and one municipal library. The ETV broadcast or open-circuit stations provide both types of broadcast service described above.

2. *Through closed-circuit systems operated by educational institutions.* No broadcast transmission is involved. Only those television sets connected to the cable distribution system are capable of receiving the instructional signal. Exclusive of the armed services, an estimated 400 facilities are in use in American schools and colleges.

The systems vary greatly in complexity. In a number of classrooms this fall the instructor will perform an experiment which, through TV magnification, his class will watch on monitors in the same room. The University of Minnesota Dental School CCTV system extends clinic instruction from one room to another. Professors of education at San Jose State College are able to discuss teaching techniques as observed by cameras unobtrusively placed in elementary classrooms in the adjoining city. All 17 schools in the Anaheim, California Elementary District are connected to a central studio adjacent to the administration building. The majority of buildings of the Hagerstown, Maryland County school system are linked in one of the oldest CCTV systems to a multistudio production center. And in the largest closed circuit system designed to date, the South

Carolina ETV Commission plans to connect its ETV Center at Columbia with all 413 high schools and 1200 elementary schools in the state by means of a system capable of providing multiple programs concurrently (cost: $3,800,000 per year).

3. *Through programing over local commercial stations which either donate or rent facilities and time.* Western Reserve University in Cleveland pioneered in presenting credit courses over commercial outlets which welcome this public service opportunity.

4. *Through similar programing over national commercial networks which clear time with their affiliated stations and arrange with local educational institutions to offer credit for completed work.* "Atomic Age Physics," NBC's *Continental Classroom* offering, and "The American Economy," presented this fall by the Learning Resources Institute over CBS's *College of the Air*, are prime examples.

5. *Through special technical systems enabling the distribution of instruction over a large or regional area.* The Texas Educational Microwave Project, wherein 11 public and private colleges in southwestern Texas are interconnected and share educational resources from campus to campus, is an example. The MPATI project described above is another.

Range of ETV

Television is being used systematically to provide American schools and colleges with four basic types of instruction:

- Total teaching, as in the case of the small rural high school outside Oklahoma City where no physics classroom teacher is available.

- Supplementary instruction, illustrated by the *"Let's Find Out"* course viewed in 119 school districts surrounding the Sacramento, California ETV station, where television science instruction teams with the classroom teacher in presenting basic subject matter.

- Enrichment instruction, as was the case last year when 5,491 classrooms within the coverage area of the Pittsburgh ETV station received desirable instruction additional to that provided by the classroom teacher—instruction which could not conventionally be presented in any other manner.

- Remedial instruction, such as at Ohio State University, where a basic level mathematics course has been offered only through a campus television system.

In the past decade, virtually every course from anthropology to zoology has been successfully presented over television: manipulative, abstract, industrial, preschool and postgraduate. Heavy emphasis has been placed on science and mathematics. As the fall semester begins, the Ford Foundation, which has provided over $81 million to local projects and the national organizations supporting the ETV movement, estimates that over six million students will be receiving a portion of their instruction by means of this medium of communication.

A quick sampling across the country reveals the following:

- In Chicago, a two-year junior college degree can be obtained through television, with infrequent trips to campus for examinations.

- At Penn State, 9,000 students will be enrolled in such TV courses as biological science, anthropology, mathematics, psychology, archeology, and zoology.

- Through its ETV station, the Des Moines Public and nearby county schools will provide regular ETV instruction to 25,000 students, with science courses recorded on videotape and rerun for the other half-day schedule.

- From an Ohio State University telecommunications center zoology 400 and 401 are repeated nine times each day for the benefit of 5,000 students.

Perhaps no other single facet of American education has been subjected to as much research and experimentation as has educational television. Both school systems and universities have mounted a wide range of experiments dealing with appropriateness, feasibility, and the effectiveness of TV teaching as compared with conventional instruction. It is fact that students do learn by television, and in many cases accomplishments exceed traditional instruction. Volumes of research reports are accessible to the interested educator.

While the past decade has provided valuable information about the successful utilization of television in education, there is much still to be determined. Current research is aimed at improved quality of instruction, the optimum lengths of a given lesson and the frequency of presentation, the relationships of pre- and post-television classroom instruction to the televised lesson itself, the relationships of television instruction to laboratory work to discussion sessions to individual counseling. One thing is sure: despite educational television's extremists, both zealous advocates and bitter reactionaries, television is succeeding in education.

Future Developments

What is in store for the next decade? As the result of recently passed federal legislation providing matching funds for capital equipment, we can expect to see the activation of a hundred additional ETV stations over the next five years. Many institutions and communities will program several broadcast stations. Pittsburgh, Miami, Milwaukee and St. Paul already have applied for or are operating two such facilities because of the quantity of programing required. Virtually every major university and school system will employ at least

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one closed circuit system. The trend is toward interconnection of ETV facilities on a statewide and regional basis, in order to share outstanding educational resources among campuses. Regular exchange already takes place through the Eastern Educational Network. As the result of an Office of Education study, a National Instructional Television Library and two pilot regional libraries have been established to assist with the exchange of quality recorded instructional materials; over 15,000 lesson units were recently reported as recorded and available. Teacher training institutions will place increasing emphasis on use of the new educational media. Television technology will continue its rapid improvement to enable better quality signal distribution and recording, and at substantially lower costs. National supporting agencies and commercial concerns will become increasingly involved in various facets of instructional television. Television will assist in the solution of a number of pressing problems at every educational level. ITV will alter the role of the classroom teacher, permit the redeployment of instructional personnel to enable better and more classroom, laboratory and research facilities, free teachers for small-group upper division courses and individual counseling. The Miami schools estimate that, without the instruction provided by their station WTHS-TV, the system would have had to invest $5,000,000 in new classroom construction and equipment. On more than one Big Ten campus this fall the large freshman classes would not have access to certain courses, were it not for television.

Television is meeting some of its greatest successes where teachers, curriculum specialists and educational media specialists cooperatively plan and produce the project. Possibly the greatest asset of ETV is its ability to bring varied educational interests to work collaboratively toward a single educational objective. The cooperative ETV councils, the summer workshops from which came redesigned curricula and the improved instruction offer varieties of proof.

Television itself is but a medium of communications; it is in itself neutral. The tubes and lens and hardware could not care less what they are being used to program. That television has great impact, educationally and otherwise, and can be used to persuasive advantage, there can be no doubt. Is it not important, then, that all those conscientiously interested in improving the quality and quantity of American education step in to see that educational television is used to greatest advantage?

Programed Instruction and the Emerging Educational Technology

Lawrence M. Stolurow, Professor of Psychology, University of Illinois

Today no one would build a bridge without taking into consideration the characteristics of the materials, the method of construction, and the design of the structure. Physical science fortunately enjoys a vigorous technology and the engineering of physical structures is a highly developed profession. We build bridges well.

Intellectual structures are built into the minds of men by the process of instruction. In this sense instruction is also engineering. However, today we build intellectual structures with only a mind to their content, the characteristics of the material. Yet we wonder why we do not build these bridges well.

One of the clear, but still weak, signs in the current educational scene, however, is the growing conception of the technological requirements and possibilities in educational engineering. The increasing demands for the acceleration and redirection of educational programs, particularly in mathematics and the sciences, produced by the joint action of new ideas and a growing demand for education give promise of a brighter future for the development of this technology. For effective use of the basic knowledge being produced by the behavioral sciences in meeting the accelerating demand for education, it is inevitable that an integrated and formal technological capability will emerge, grow, and become strong.

The new media are the foci of this emerging technology, and one of the newer and more promising is programed self-instruction (PSI) which frequently, but not always, uses a teaching machine. Careful examination of this particular medium quickly reveals that it is not its elements that are new, but rather the organization of them, the conception into which these elements are interrelated, that makes this an innovation of potential practical and theoretical value.

Socratic Method

Fundamental to PSI are contributions from philosophy, engineering and psychology. The contribution from philosophy is the Socratic method of asking rather than telling. The contribution from engineering is the concept of feedback. Psychology not only contributed support to the importance of feedback through research on reinforcement, but has also contributed studies indicating many of its significant characteristics. In addition, psychology is producing information critical to the third dimension of PSI, namely, principles of program organization and design. A program should not be amorphous and, desirably, it should have a structure relating to its purpose. It is made up of a set of elementary parts called frames or steps and these building blocks provide the student with the informational content he is to learn. The internal organization of each frame, as well as their sequence, are two of the important but poorly understood problems in this area. This is where research is needed today. Hopefully, it will be forthcoming soon.

PSI can be defined as any combination of conditions that provides a stimulus to a learner, permits him to make a response (either covert or overt and covert), and informs him of the nature of the correct response before providing him with new stimulus information so that the process can be continued. Coupled with this basic set of requirements are those of program design. In PSI a stimulus frame is any set of signs or symbols to be related to the learner's responses. Distinctions are often made between *transitional* and *terminal* frames where the former are either a means to an end or are modules to be grouped so as to form larger units. Earliest efforts at PSI were only two dimensional in that they were Socratic and provided feedback. Most recently the third dimension of programing has been added and it is a primary concern, as well as an important hope not only for the future development of PSI as an applied technology, but also for the

theoretical development of our understanding of the conceptual organizational needs of each student. In this dimension lie the basic problems of instruction no matter how it is conceived and conveyed. Consequently, PSI has an important potential contribution to make to education in general and particularly to the instruction process.

A potential source of possible potency in PSI lies in facets not shared by the other media. First, it is individual, not mass, instruction; yet it can be multiplied economically so that it is feasible to employ it on a large scale. Second, it provides direct and immediate feedback each step of the educational journey taken by the student. He knows immediately when he is right and when he is wrong. Third, it can be planned to respond to individual differences; it is an adaptive medium in that differing responses of learners can be anticipated and provided for so that either remediation or enrichment can be made available as individually required. Fourth, it is the only medium that permits the collection of a collated response record from every student. While this may seem unexciting, it is certainly not trivial and, in fact, turns out to be important for the refashioning and systematic improvement of programs. It is the behavioral data provided in a collated manner which make it possible for the programer to revise and progressively improve the program. Furthermore, this feature of PSI gives priority to student needs rather than teacher convenience, for if a program produces too many errors it is rejected, not the student. Thus, the collated response record contributes to the development of more effective teaching methods rather than greater refinements in student selection procedures. Thus we see the psychology of learning rather than of testing as the dominant area of educational psychology in the future.

Potential against Social Ills

These and many other features of PSI have been recognized all too quickly by the more enlightened educator and enterprising industrialist. The momentum produced by the interest and demand for programs and information has caused concern and consternation among the behavioral scientists who were busily trying to perfect PSI before making it known to the educational world. Many feel that the present situation in which they find themselves is not too unlike that of the physical scientists who worked on the atomic bomb. Both groups developed a weapon before they had time to think about the full implications of its use for applied and theoretical purposes. PSI is a potential weapon against twin social ills —illiteracy and ignorance. While this is quite clear, it is not clear what the formula should be for its most efficient and effective use for these different purposes and under the variety of conditions that have been suggested and considered for its practical application.

Teamwork Needed

Teamwork is obviously required and fortunately seems to be developing in the effort to work out these problems. Teamwork between psychologists, content specialists and school personnel appears to be both indicated and potentially fruitful for all concerned. As an approach to the problems faced in making PSI a real, rather than a potential, force in contemporary education, a team effort has much to recommend it. Few, if any, could master all the requisite skills and turn out the materials needed.

Since the demand for programed materials is high and appears to be growing, there is further cause for concern. While competent teams are working on materials in some areas, e.g., in mathematics, the University of Illinois Committee on School Mathematics and the School Mathematics Study Group, many areas are going begging and incompetent teams may be formed to fill the breach. *Programs, '62 A Guide to Programmed Instructional Materials Available to Educators by September 1962* [1] lists 122 programs. The bulk of these are for use from grades four through thirteen, and the largest number at any one grade is 31 at grade eight. Few are available at the primary grade level and almost none exist for special education—for the mentally retarded, deaf, blind, or multiplely handicapped.

The largest number of programs, 43.5 per cent of the 122, are in mathematics; 18.9 per cent are in sciences; the third largest group is in grammar, usage and spelling, 17.3 per cent. Other areas covered are, in decreasing order of their number, language arts, social sciences, business education, music and programing.

In terms of hours of programed material, again mathematics leads by a large margin (49.2 per cent of the 2,602 hours available in 72 programs); sciences are second (13.8 per cent); followed by modern language (13 per cent); grammar, usage and spelling (8 per cent); business education (6.4 per cent); social sciences (4.6 per cent); language arts (4.2 per cent); music (.7 per cent); and programing (.1 per cent). Thus we see that the field is developing rapidly, on the one hand, and on the other hand there is a long way yet to go in meeting existing school and college needs. Most of those available are "short programs." The typical length is less than 1000 frames; about 5 per cent are over 10,000 frames long and provide as much as forty hours of instruction. Costs also show wide variation per hour of instruction: mean $1.52; median $.53; range $.08 to $8.33 (based on 72 programs). The cost per frame based upon 83 programs varied from .1 of one cent to 18.5 cents with a mean of .9 of one cent, and a median of .6 of one cent. Quality cannot be judged by cost figures. It should be determined by "external" criteria such as student performance on a valid test of the program's objectives. The evaluation of programs is a knotty problem and the techniques and standards are currently being studied by a "Joint Committee" of persons representing the American Psychological Association, the American Educational Research Association, and the Division of Audio Visual Instruction. A revision of their first set of recommendations will soon appear and later effort will go into the preparation of a more complete and technical pamphlet.

[1] Available from U. S. Government Printing Office, OE 34015 ($1.50).

Accelerated Learning Possible

In 1961 *(Teaching by Machine)* it was reported that 27 research projects dealing with PSI were being supported by the "New Educational Media Program" of the U.S. Office of Education, Title VII of the National Defense Education Act of 1958. Federal funds totaling approximately $1.87 million were obligated to bring these research projects to completion. The number of projects and amount of support here increased appreciably in 1962 not only by governmental agencies but also by private foundations and industry. Research studies are both basic and applied, both substantive and methodological. The results thus far are both encouraging and discouraging but in general indicate that with PSI students learn, the brighter ones move ahead more rapidly than they would by group-paced methods, and students like good programs but dislike poor ones.

The implications are not all clear,

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but one is: namely, that PSI will lead to the construction of better instructional materials. Even if PSI does not become widely used in the classroom and remains an educational research technique, instruction is bound to be better for its development and use, since it requires of the programer meticulous attention to the "fine grain" as well as the overall pattern and objectives of instruction. The exercise of developing a program is both intensive in its analytical demands and rewarding in the new insights it provides. The real payoff and the big surprises occur when it is given to students and you see the important contribution they can make to your understanding of their needs and the techniques you used.

Accelerated learning of many students who are not now allowed to develop at the rate they are capable of, is another real possibility. A third prospect is a greater awareness of the educational implications of individual differences in aptitudes and abilities, particularly as these differences relate to the need for different instructional methods and conceptual sequences. Preliminary data suggest that different sequences of the same set of frames place different demands upon the learner in terms of the abilities they require for equivalent achievement. Effective programing appears to be capable of making lower ability students able to achieve, as well as students of substantially higher general intellectual ability, but the number of I.Q. points that can be compensated for by different procedures remains to be determined. Preliminary data also suggest that it might be possible to develop cognitive strategies and styles through PSI. This appears to be a fertile field for further development. It could provide the needed knowledge for an educational technology capable of efficiently building effective intellectual structures.

Help for 100

The School Mathematics Study Group has extended a hand to high school teachers who encounter extraordinarily gifted students in their mathematics classes. But, says SMSG, please don't write about students who are merely ready for calculus by the twelfth grade or who like to read books about mathematics in addition to doing course work. Such students are superior and exist by the thousands over the country.

How to tell the extraordinarily gifted? Well, SMSG says, if, with no outside assistance, he can read and understand a large part of *A Survey of Modern Algebra* by Birkhoff and MacLane, you had better write for help. There are probably less than 100 such high school students in the country, SMSG estimates.

Teachers confronting such mathematical minds can get aid from SMSG's Committee on the Extraordinarily Gifted Student, Stanford University, Stanford, California.

Recent Publications

The bibliography below was prepared by **Dr. Donald J. Dessart,** State University College, Oneonta, N. Y.

Brown, Kenneth E., and Snader, Daniel W. *Inservice Education of High School Mathematics Teachers.* U. S. Department of Health, Education and Welfare, Office of Education, Bulletin 1961, No. 10, 1961. 108 p.

Reports of conference held under the joint auspices of the U. S. Department of Health, Education, and Welfare and the National Council of Teachers of Mathematics for the purpose of investigating ways of improving inservice programs for secondary school mathematics teachers. Includes formal papers that were presented and summarizes work session deliberations and panel discussions.

Mathematical Sciences Section, National Register of Scientific and Technical Personnel. *Professional Characteristics of Mathematical Scientists.* Providence, Rhode Island: The Register, April, 1962. 4 p.

Summarizes the following characteristics of the mathematics field and its personnel, based upon data compiled during 1960: age of mathematicians, growth of opportunities in the mathematical sciences, patterns of degree attainment, types of employment and work activity, and characteristics of the various subfields of mathematics. Further statistics reveal that greater numbers are entering mathematical fields than in the past, but there are not proportionate increases in the numbers continuing study toward advanced degrees.

May, Kenneth O. and Schuster, Seymour (Editors). *Undergraduate Research in Mathematics:* Report of a Conference held at Carleton College, Northfield, Minnesota, June, 1961. Northfield: Carleton Duplicating Service, 1961. 96 p.

Reports a conference held under the auspices of the National Science Foundation for the purpose of exploring programs of undergraduate research in mathematics. The report is devoted largely to addresses delivered by prominent college and university professors of mathematics on methods of conducting such research programs.

National Association of Secondary School Principals. *The Bulletin: Junior High School Development, Practices, and Research.* Washington, D. C.: The Association, February, 1962. 478 p.

Provides a discussion of recent developments and practices in the junior high school, followed by a rather comprehensive collection of 174 abstracts of research conducted in the junior high school during the past five years. Fifteen of these 174 studies concerned problems in mathematics teaching of which four were in the area of evaluation, three in curriculum development, and eight in teaching methods.

National Commission on Teacher Education and Professional Standards. *New Horizons: The Becoming Journey.* Washington, D. C.: N.E.A., 1962. 167 p.

Reports the Pennsylvania Conference (the sixteenth annual National TEPS Conference) held at the Pennsylvania State University during June, 1961. The report evidences the efficacy of the cooperative approach of academicians, the educationists, college staff members and schoolmen, researchers and practitioners, and teachers and administrators in the improvement of teacher education and professional standards.

National Council of Teachers of Mathematics. *The Revolution in School Mathematics.* Washington, D. C.: NCTM, 1961. 90 p.

A report of the proceedings of eight regional conferences conducted to give school administrators and mathematics supervisors information that would enable them to provide leadership in establishing new and improved programs. The cause and direction of this revolution is examined, as well as the administrative decisions it calls for at the local school level.